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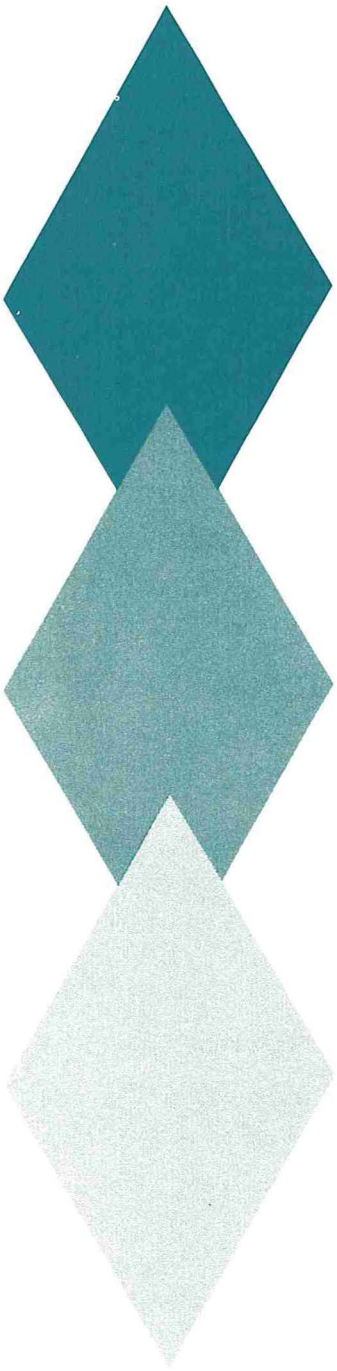

# DETERMINING AND SATISFYING DRIVERS' INFORMATION NEEDS RESULTS OF NCHRP PROJECTS 3-12 AND 3-12/1

by

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Presented before
COMMITTEE ON COMMUNICATIONS
AMERICAN ASSOCIATION OF
STATE HIGHWAY OFFICIALS
Houston, Texas
November, 1970

AIL a division of CUTLER-HAMMER

DEER PARK, LONG ISLAND, NEW YORK 11729

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Committee on Communications
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# I. BACKGROUND

Work on NCHRP Project 3-12 was started by AIL, a Division of Cutler-Hammer, Inc., on October 1, 1966. The original project was designed to elicit answers to the following questions:

1. What information is needed by the highway users for their safe, convenient, efficient, and comfortable performance of the driving task?
2. What are the principal factors and interactions underlying the selection and transmission of this information?
3. To what extent can visual communications be used successfully?
4. Are supplemental communication techniques needed? If so, where and how could they be applied effectively?

A final report on this project was submitted to NCHRP in December 1967. Based on the results of this study, NCHRP authorized a continuation project designed to address itself to certain specific points raised in the original project. The specific points, on which work started in April 1968 were:

1. To present the functional design of a proposed information system conforming to the concept developed during the research conducted under Contract HR 3-12 (AIL Project 2024).
2. To conduct an in-depth evaluation of an existing highway information system.
3. To present a suggested method of evaluation effectiveness of information systems.
4. To develop further the system application procedures developed during the course of research and information found under Contract HR 3-12.
5. To present an improved procedure for sign design.

6. To present as part of the final report a working manual to facilitate the use of the research findings.

A final report, integrating the results of both studies, was delivered to NCHRP in December 1969.

This report amounted to four volumes containing nearly 1000 pages and weighing 11 pounds. The present paper is intended to summarize this report and to present the more salient findings of the study.

## II. THE DRIVING TASK

The purpose of information is to reduce uncertainity. As long as uncertainty exists, alternate possible decisions cannot be fully evaluated. In order to make rational decisions, the driver must reduce his uncertainty. The need to reduce uncertainty generates an information need that requires information for its satisfaction.

AIL thus started its investigation of the drivers' information needs by determining what the driver does. This analysis of the driving task gave an indication of the decisions that have to be made by the driver and, therefore, of the information required to make the decision.

It was found that the driver performs a number of interrelated subtasks, some of them simultaneously. In seeking an overall concept of the driving task, attention was given to the interrelationships between the subtasks. It was noted that these subtasks could be ordered into a hierarchy that describes the organizational content of the driving task. The hierarchy itself could be ordered according to time scale and level of cognitive activity. The subtasks differ in the time scale relevant to their analysis from fractions of a second for steering to minutes or hours for trip route finding. They also differ in the level of cognitive (mental) activity required of the driver. The cognitive activity required for steering is nonverbal, highly overlearned by

experience, and might be performed by an animal capable of operating the controls. The task of route finding, on the other hand, requires thinking in terms of abstract symbols, language, and maps.

Tracking and speed control, which are continuous throughout the driving task, are involved in the performance of all subtasks higher in the hierarchy. Route finding and trip planning affect all subtasks responding to road and traffic situations.

## A. LEVELS OF PERFORMANCE

Since the vehicle-control task low in the hierarchy are those observed in looking at the fine detail of the driving task, they are referred to as microperformance. The term macroperformance refers to the large behavioral units at the other end of the hierarchy. Since the remaining tasks in between consist mainly of responding to roadway and traffic situations, they are referred to as situational performance.

### 1. MICROPERFORMANCE

At the micro-level, there are two main subtasks: steering and speed control.

On a flat, straight road the driver observes his lateral motion in relation to the road, and applies minute corrections to the steering wheel to maintain a steady state. The times required for such corrections are of the order of one-half second. On horizontal curves, larger movements of the steering wheel which may extend over several seconds are required to maintain lateral position.

The steering task depends on the driver's spatial orientation with respect to the roadway immediately and farther ahead of him. Feedback information of the vehicle's response to steering wheel movements is also necessary.

In addition to the kinesthetic feedback through his hands and arms, which tell how much the steering wheel is turned, the driver needs visual feedback of changes in the car's position and orientation with respect to the road.

Tracking performance is heavily overlearned so that it can, in most driving, be carried on without conscious attention. However, emergency situations may call for steering performance beyond the limits of the driver's experience, and he may lose control of his vehicle.

Assuming automatic transmission, speed control requires the operation of two controls: the accelerator and the brake. To maintain a steady speed on a flat road, the driver's task is comparable to steering on a straight road, requiring only minor adjustments. Changes in vertical alignment require changes in accelerator pressure, or even use of the brake pedal. Although wind and engine noise, and the speedometer, provide speed cues, previous research indicates that visual cues are of primary importance in speed control.

Each subtask affects the performance of subtasks lower in the hierarchy. Here it is clear that speed control affects steering, even in simple cases. The speed of the vehicle on a given horizontal curve affects steering greatly, and braking to the point of skidding makes steering control almost impossible.

## 2. SITUATIONAL PERFORMANCE

This level of performance refers to the influence of elements of road, traffic, and external environment, as well as other miscellaneous factors which cause the driver to initiate complex control sequences to either return to a subjective steady state, or modify the subjective steady state.

Situational performance can be characterized as being concerned with the driver's objective of maintaining the most efficient and safe course,

relative to factors in the environment which are generally beyond his control. As the term situational performance implies, the performance at this level is a function of the driver's perception and ability to cope with the situation. Therefore, the driver must have a store of a priori information on which to base his control actions, as well as an understanding of what the situation demands.

Perhaps the least complex of the situational performance activities is that of car following since the only deviation from the steady state microperformance activities involves speed control modifications. In car following, the driver is constantly modifying his car's speed to maintain a safe gap between his car and the vehicle that he is following. In this situation, he is time-sharing his compensatory tracking activities with a more complex speed control activity.

A second situational performance activity that commonly occurs is overtaking and passing which involves, in addition to speed control, modifications in the basic compensatory tracking activity.

There are many other situational performance activities such as avoidance of pedestrians, response to traffic signals, advisory signs and railroad crossings. The important point, from an information standpoint, is that the driver must receive information about the situation so that:

1. He is aware of the occurrence of a situation.
2. He knows what the situation is.

Furthermore, he must possess the skills and a priori knowledge that will enable him to made the appropriate tracking and speed control responses. He should also have information that will indicate the adequacy of his responses.

At the situational performance level of driving behavior the driver is constantly time-sharing activity at this level with that at the microperformance level. Situational performance needs do not necessarily occur

enough time to make a decision, leading to confusion or decision making on the basis of imcomplete information.

One way to avoid the problem caused by too few or by too many signals is by applying the principle of spreading. In applying this principle of spreading a processing capacity profile, with peaks (too much information) and valleys (too little information), is determined. The objective primacy of the situation is determined and the less important information needs at the peak where too much is occurring are transferred to the valleys, thus approaching an even distribution of information presentation and minimizing the problems of low and high signal areas.

5. EXPECTANCY

Expectancies are a function of the driver's experience and a priori knowledge. An important part of driver education is the development of a set of realistic expectancies.

Microperformance expectancies are those associated with the vehicle and its position on the road. That drivers expect their vehicles to respond to their control actions is indicative of expectancy at this level. Once position on the road has been established, the driver relies on inference and prediction to maintain his position on the road. Anything occurring that is not within the realm of what the driver expects can lead to trouble. Microperformance expectancies operate below the level of consciousness.

The importance of expectancies is perhaps the greatest at the situational level. Alignment changes provide examples of how expectancies at this level can be structured. Drivers expect some alignment changes on all roads, and depending on their experience on the particular type of road, expect to make speed and tracking corrections. Warning signs must be used to structure driver expectancies. Few drivers expect lane drops and other changes in cross-section. Therefore, warnings of these changes are necessary.

Another class of expectancies involves interchange configurations, such as whether exits are on the left or right. Since left exits and entrances are seldom encountered, they are counter to driver expectancies. Presently, very little information on type and configuration of interchange is presented to the driver. His expectancies are rarely structured except by a priori knowledge.

If a car's left-turn signal is on, the car is expected to turn left. Similarly, when approaching a green light, the driver expects cross traffic to stop. Intervehicular signaling is indicative of expectancy structuring at this level.

The final category of expectancies involves direction finding and service. An important aspect of this phase of expectancies is that they are most amenable to structuring since so much of the macroperformance is involved in pretrip preparation. The driver expects to find in-trip cues that correspond to his trip plan. He expects to find signs telling him where he is and which way he is going. He also expects to find information telling him where services are located and how to get to them. At the macroperformance level of driving, the greatest potential exists for structuring expectancies (through maps) and then satisfying these expectancies, (through signs).

## 5. SUMMARY

The basic tenets for the systematic presentation of information needed by the driver are:

- First things first--primacy
- Don't overload--processing channel limitations
- Do it before he gets on the road--a priori knowledge
- Keep them busy--spreading
- Don't surprise them--expectancy

As part of this project, a detailed case-study analysis (which is too lengthy to detail here) was made to show how application of these principles to the presentation of macroperformance information would result in changes in current practice.

## IV. SPECIFIC TOPICS

In addition to the basic work on the fundamentals of information system design, described above, several specific topics of importance in the application of information systems, were investigated.

### A. SIGN DESIGN

Considerable effort was devoted to a study of the factors influencing the design of highway signs. The principal output of this phase of the research was a computer program which determines the legibility of signs under night time conditions when illuminated only by a vehicle's headlights.

For a set of pre-selected parameters, including highway alignment, vehicle type, and sign position and material, the program computes and outputs the apparent luminance, at the driver's eye, at various distances from the sign. Using empirically derived luminance-legibility relationships, available in the literature, and computed legibility distances, these luminance values can be used to determine required letter sizes.

The program was first used to determine the changes in luminance occuring as a result of varying one of the input parameters. Figure 2 represents an example of this investigation. In this specific case the parameter being varied is horizontal alignment, specifically the deflection angle and degree of curvature of a horizontal curve to the left. Figure 3 represents another example. In this case the parameter being investigated was headlight mis-aim. In all, this phase of the investigation included investigations of the effect of four different cars, on high and low beam, 13 road alignments,

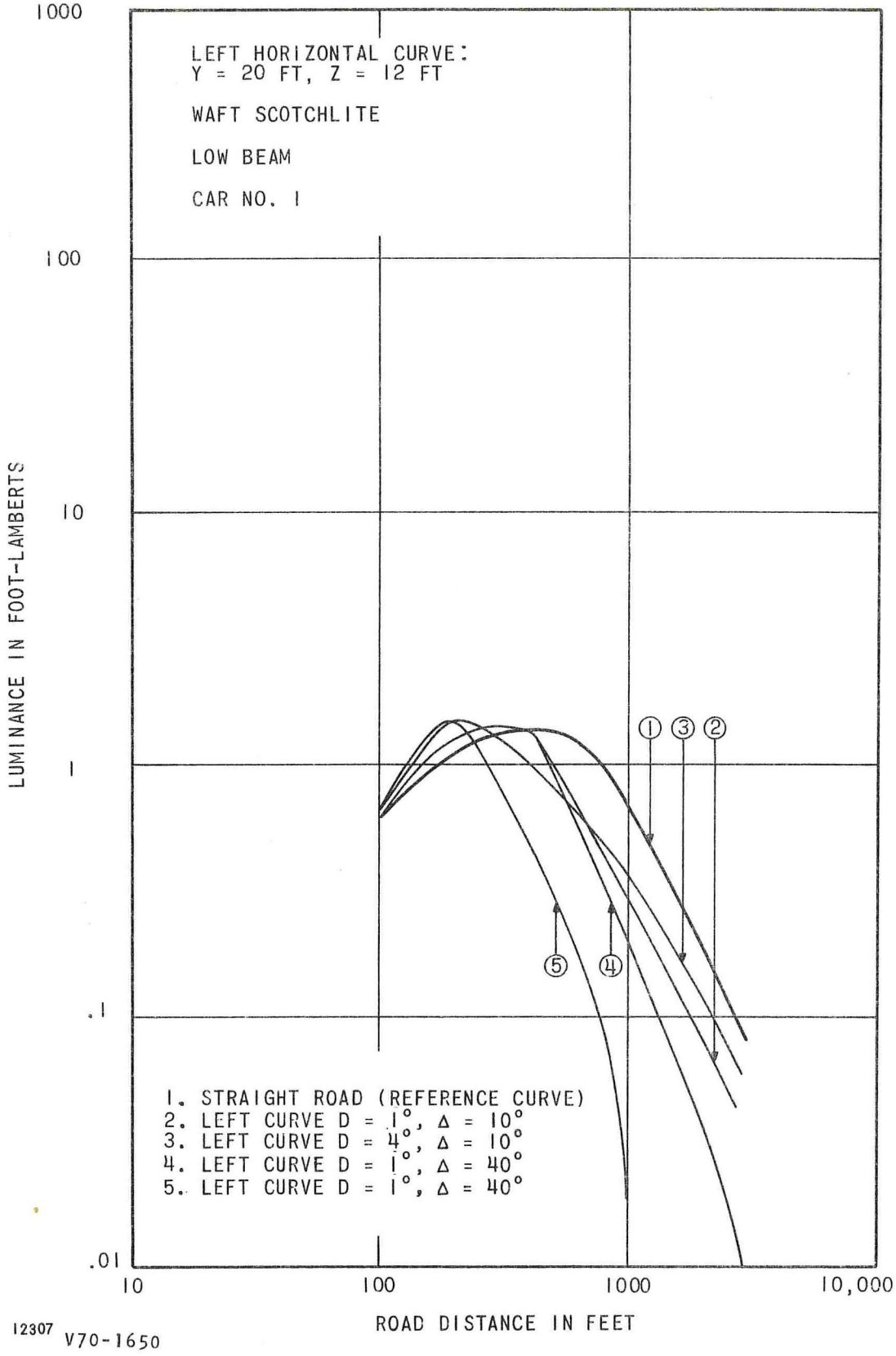


FIGURE 2. SIGN BRIGHTNESS: ROADSIDE POSITION ON LEFT HORIZONTAL CURVE

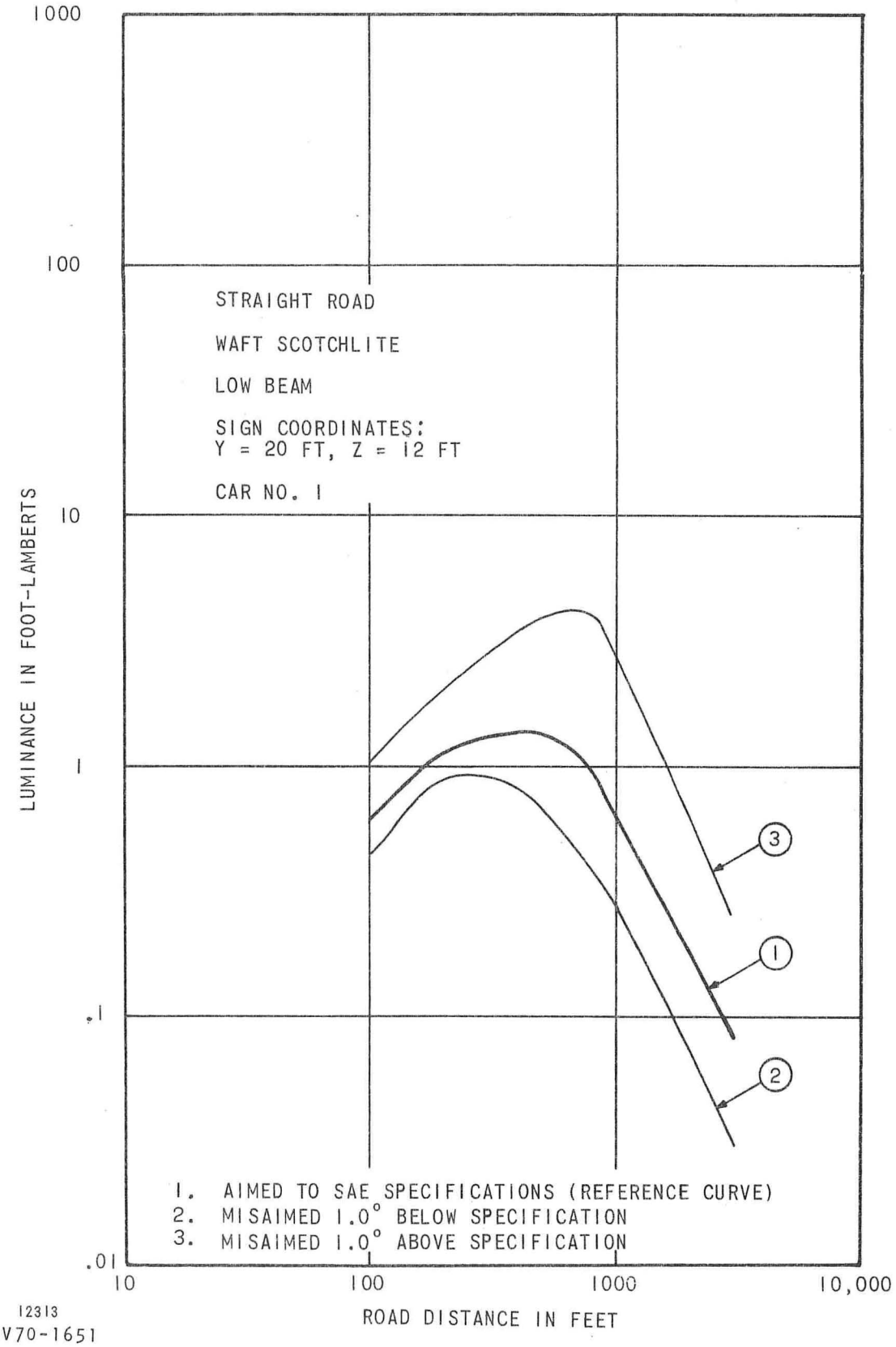


FIGURE 3. SIGN BRIGHTNESS: MISAIM EFFECTS

three types of retro-reflective sign material, six sign positions, as well as mis-aim, atmospheric transmissivity, and aging of the sign material.

The second effort under this heading was an investigation of the signing actually in place on a completed section of Interstate Highway. A total of 63 signs installed on 20 miles of I85 in North Carolina were investigated. The signing met all applicable requirements of current Manuals and design standards. However, as can be seen from Figure 4, considerable deficiencies in legibility were noted. Two bar charts are shown, one for all signs, and one for guide signs only. The numbers along the abscissa represents difference from computed minimum letter size requirements, expressed in terms of standard letter sizes (usually 2-inch increments). The bar labeled infinity represents that percentage of signs that cannot meet legibility requirements with any letter size. Figures 5 and 6 are cumulative distribution.

Although this methodology was developed for the investigation of fixed highway signing using retro-reflective material and illuminated by a vehicle's headlights only, relatively minor changes in the program would make it applicable to internally or externally illuminated signs or to changeable message signs.

## B. TRUCK BLOCKAGE

Another topic of interest was a mathematical investigation of the effect of truck blockage on sign visibility. The geometry of the blockage problem is shown in Figure 7. A driver in a car, following a truck, will be in the truck's shadow, with respect to a sign, for a given proportion of time that the sign would normally be in view and be legible. The results of the investigation are shown in Figure 8. This figure shows the probability of a car being blocked at least p percent of the time for all lanes of a four-lane highway. Figure 9 shows blockage for both one and two trucks.

The investigation was made using random car and truck arrivals and spacing. The numerical results, therefore, can only be used to indicate

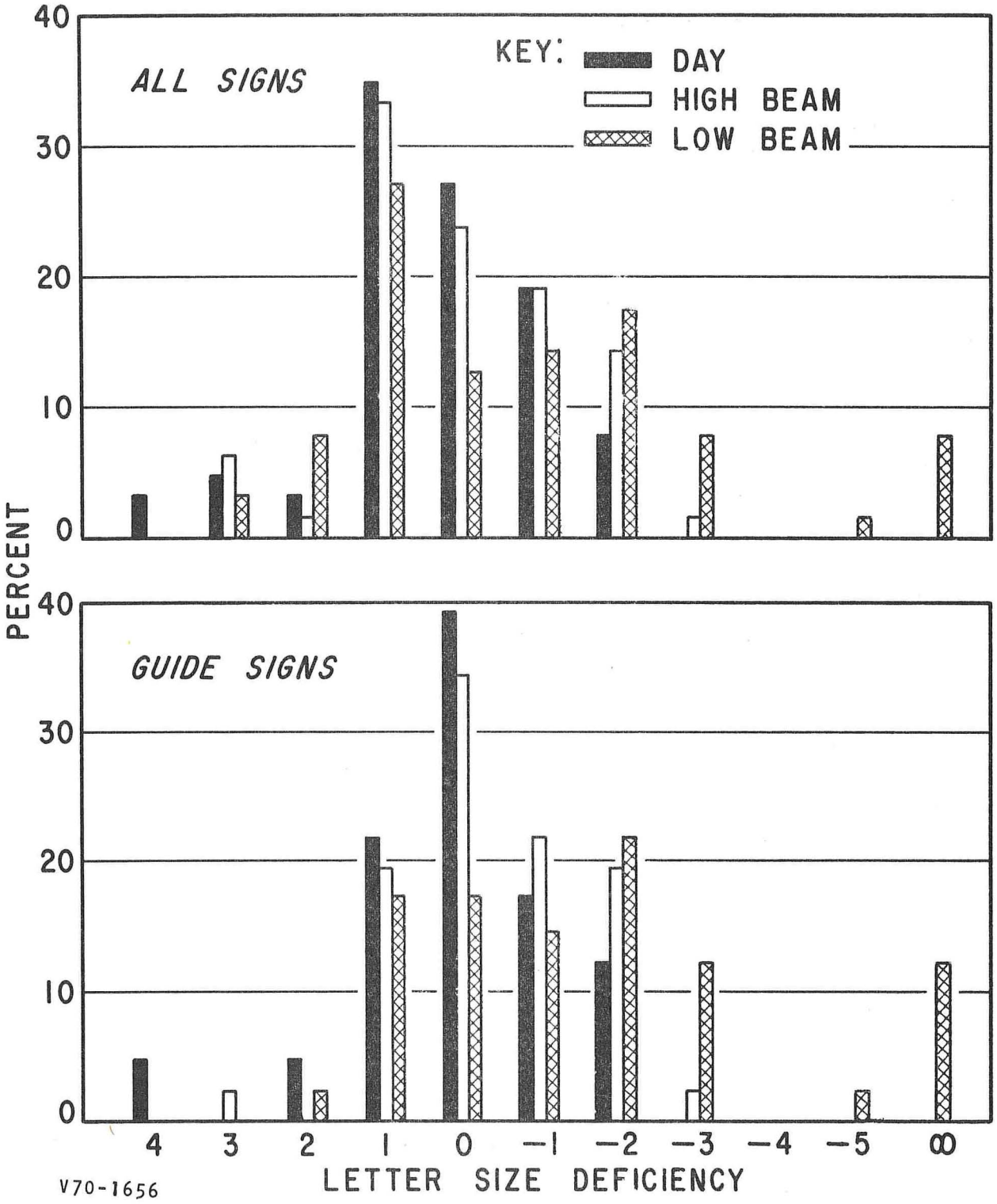


FIGURE 4. DISTRIBUTION OF LETTER SIZE DEFICIENCIES

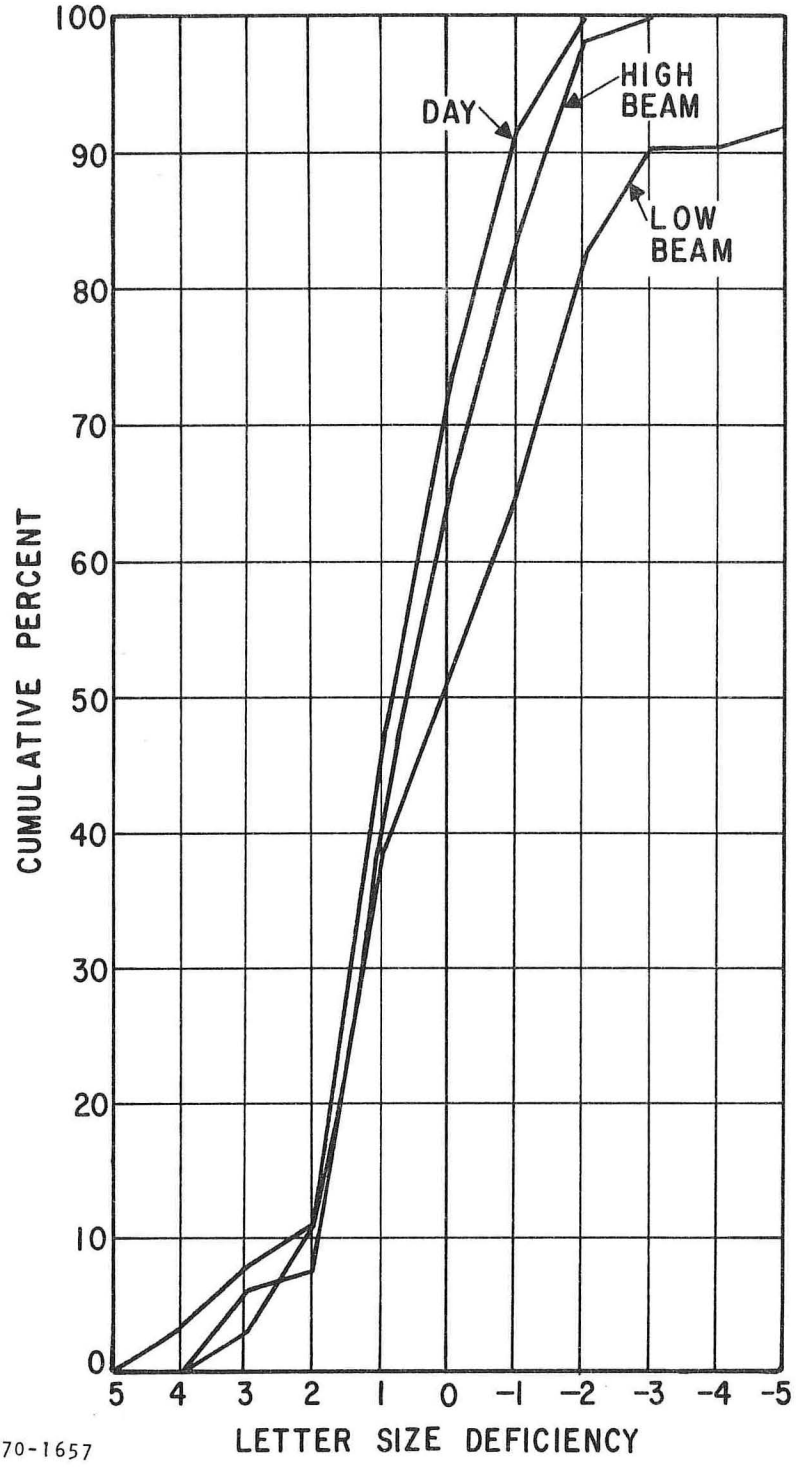


FIGURE 5. CUMULATIVE DISTRIBUTION LETTER SIZE DEFICIENCIES ALL SIGNS

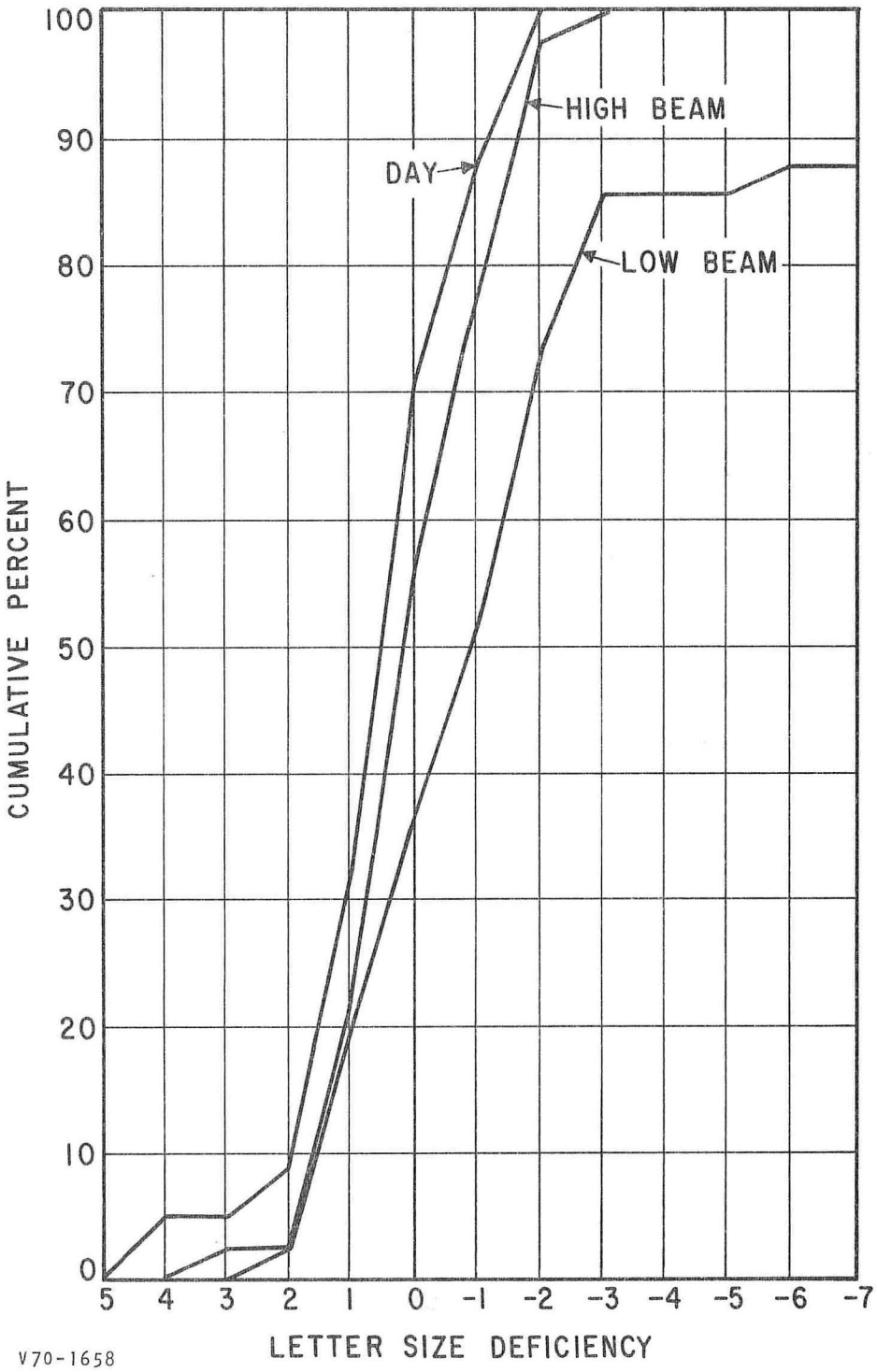


FIGURE 6. CUMULATIVE DISTRIBUTION LETTER SIZE DEFICIENCIES GUIDE SIGNS ONLY

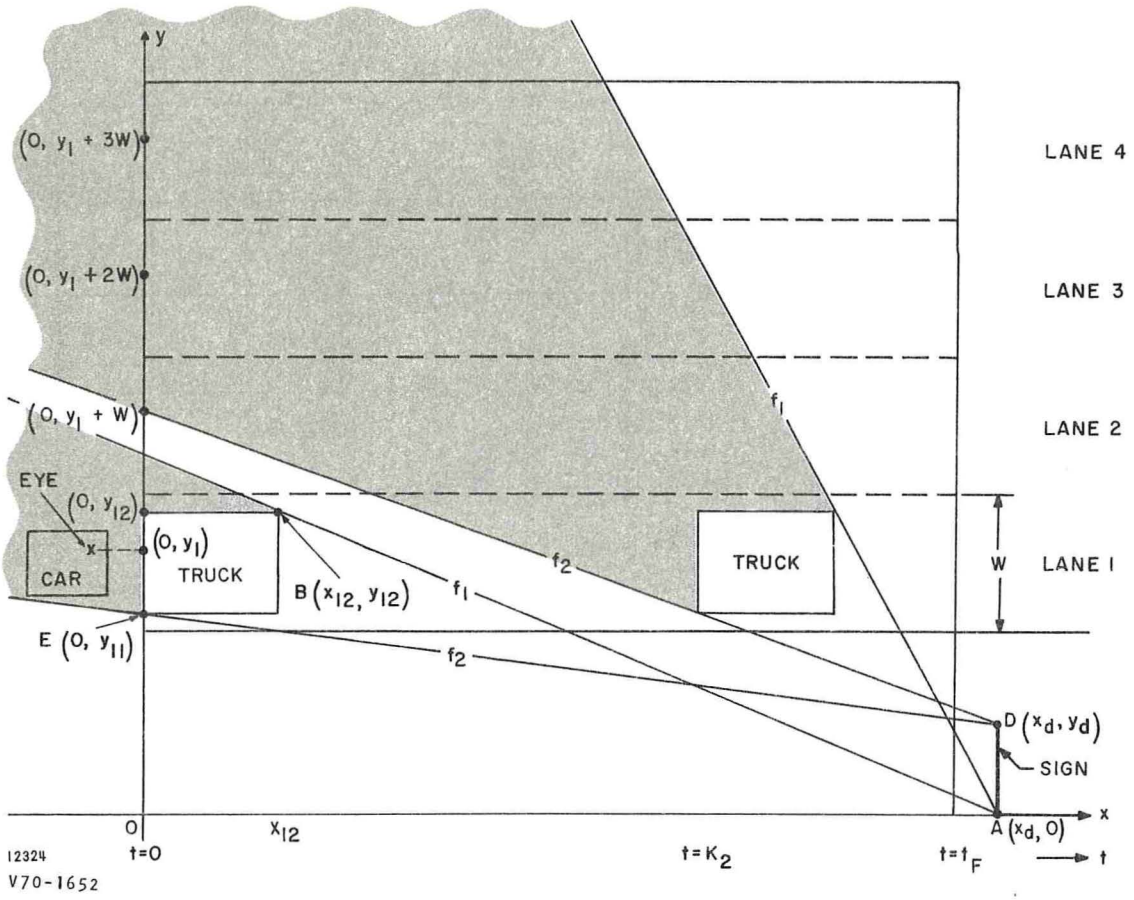


FIGURE 7. GEOMETRY OF BLOCKAGE PROBLEM

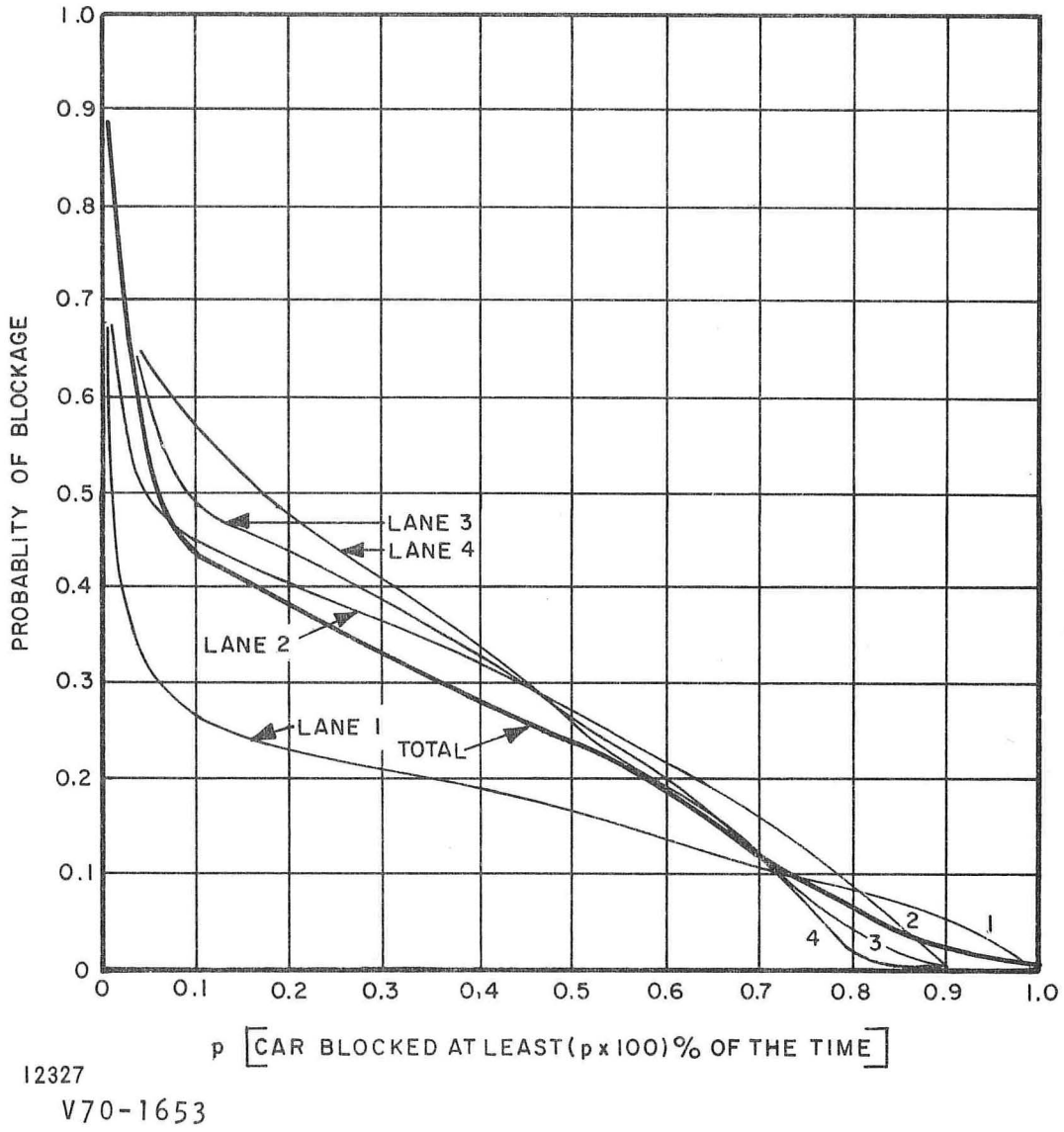


FIGURE 8. PLOT OF PROBABILITY OF BLOCKAGE VERSUS p FOR ONE TRUCK

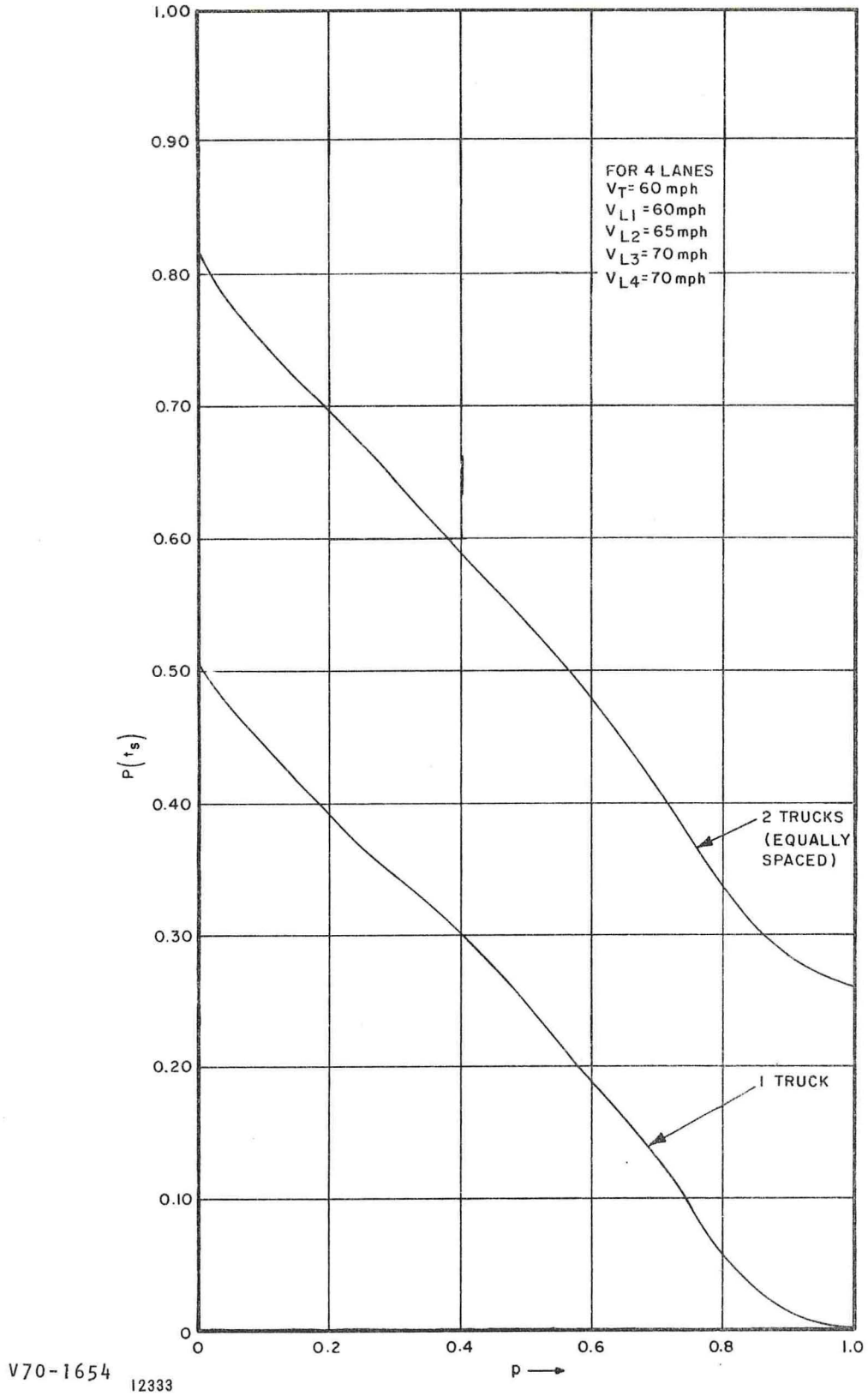


FIGURE 9. PLOT OF PROBABILITY OF BLOCKAGE VERSUS p FOR ONE AND TWO TRUCKS

trends and the order of magnitude of the problem. However, with the analysis methodology developed, it will be relatively easy to apply it to empirically determined car and truck distributions, and traffic stream parameters, to obtained practically usable results for specific highway conditions.

Although this investigation was carried out within the context of a study of highway signing, with visual blockage being of main interest, the methodology is obviously applicable to any source, such as infra-red, micro-waves or laser, which depends on straight-line transmission of either information or actuating signals for in-vehicle displays.

## C. SUPPLEMENTARY TECHNIQUES

An extensive survey was made of possible information aiding techniques using technologies other than fixed highway signing. This survey included intra and inter-vehicle communications, the use of variable message and/or variable position signing, and the transmission and reception on other than the visual channel. These were analyzed in terms of their potential for satisfying each type of information need and in terms of the type of in-vehicle and on-highway equipment that would be required.

This survey, when combined with the basic principles described above, led to the conclusion that electronic aiding techniques would have their maximum potential use in meeting situational and microperformance needs. A great potential for improvement was found in current methods of information display concerning vehicle operating conditions and handling characteristics. Inter-vehicle and road-vehicle communications, for the purpose of meeting situational information needs, were found to have the highest potential payoff for the application of sophisticated aiding devices.

# APPENDIX A

# EXCERPTS FROM FINAL REPORT ON NCHRP PROJECT 3-12/1

Summary of Findings

General Table of Contents

Conclusions and Suggested Research

## SUMMARY OF FINDINGS

1. A team of engineers and psychologists studied drivers' information needs and the means of satisfying them. Through the technique of task analysis, a body of information needs was identified, the satisfaction of which enables drivers to perform the driving task safely, conveniently, efficiently, and comfortably. Principal factors were defined which organize the needs into functional groups, delineate the interactions between them, and identify the criteria for selecting and transmitting needs to be satisfied.

Analysis of the driving task disclosed that the operations that a driver performs can be characterized in terms of a hierarchy. The basic tasks of tracking and speed control (called microperformance) are at one end of the hierarchy, direction finding and trip planning (called macroperformance) are at the other end with driver responses to road and traffic situations in the middle. Driver information needs were arranged in accordance with this hierarchy. A demanding priority (primacy) exists in satisfying information needs, with micro needs having priority over situational and macro needs. Satisfying this primacy of information needs is basic to the design of a highway information system.

Another key factor in the performance of the driving task is that of expectancy. When a trip is planned, the driver forms expectations of the conditions to be encountered in transit. Expectations are also formed, while driving, regarding roads, signs, services, etc. These expectations operate in such a manner as to provide the driver with a basis for planning his trip as well as providing him with information about what directional information he should expect in transit, when to expect it, and what it should look like.

On the basis of these principles, as applied to actual sections of Interstate and rural arterial highways, a procedure was developed to

permit the systematic application of pertinent human factors principles to the review of information system designs. The procedure was formalized into a "Manual on Information System Design Procedures." This manual, in addition to an iterative formal procedure that can be used for the review of proposed signing plans contains a section in which are abstracted and defined human factors principles useful to the traffic engineer.

2. The role of signs in a highway information system, as well as several aspects important in the design and use of fixed highway signing, was analyzed in detail. It was found that signs could, and should, continue to be the main information carriers.

Detailed attention was paid to the design of signs for night legibility. A computer program was developed to determine night legibility of signs and the variation of legibility with variations in several important parameters determined. The program was used to analyze existing signs on a stretch of I-85 in North Carolina.

Conclusions were drawn concerning the adequacy of sign design criteria contained in present manuals. It was found that legibility of signs varies greatly with apparently minor changes in approach horizontal and vertical alignment. It was also found that overhead signs are inadequate if illuminated only by the low beam headlamps of an approaching vehicle.

The possibility of blockage of signs by trucks was modeled mathematically and, under certain conditions, it was found that this potential blocking could represent a serious problem in the proper reception of information by drivers.

The effect of lateral displacement of signs on required letter height was analyzed and it was found that considerable increases in required letter height may be required if signs are offset, as recommended, to create clear recovery areas.

3. Other areas covered included the following:

a. A simulation of the probability of detecting driver "confusion" by measuring parameters of the traffic stream. Only gross changes in driving behavior, by an appreciable portion of the total traffic, could be detected by such means.

b. The basic principles derived were applied to the specific problem of presenting directional information. The concept of serving all drivers legally on the road lead to the conclusion that it is impossible to give complete directional information to all potential destinations while enroute. Emphasis is therefore placed on the construction of a trip plan which becomes part of the driver's "a priori" knowledge. Thus, the role of the macro (directional) information system is to serve as a validity check on the trip plan and a means to implement it. This should be achieved by concentrating on clear, unequivocal identification of highway links by designation and direction. The various existing and potential means of doing this, via the visual channel, are discussed and a consistent system of macro information transmission, analyzing all factors affecting the what, where, and how of presenting this information, is developed.

c. Possible supplementary techniques, using technologies other than fixed signing and/or transmission and reception of information on other than the visual channel, were evaluated in terms of their potential for satisfying each type of information need and in terms of the type of in-vehicle and on-highway equipment that would be required.

d. Current mapping practices were analyzed to determine the ability of available maps to satisfy drivers' information needs. Considerable improvements in map standardization and usability are possible. Too little is known concerning the ability of drivers, on a population basis, to use maps properly and to derive the desired information from them.

4. Suggestions for further research include:

a. Additional validation and codification of the Design Review Manual.

b. Development of the sign legibility computer program to develop a handbook of nomographic solutions to sign design problems.

c. Extension of the truck blockage model to observed distributions and validation and calibration of the model.

d. Development of uniform mapping practices and studies of the population map reading skill level.

e. Specific problems of sign design.

f. Human factors studies on information-processing capability.

g. Aiding techniques for situational performance.

h. Aiding techniques for alternate routing.

i. Studying improved means for advising drivers of unusual or unexpected conditions.

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## CHAPTER V. CONCLUSIONS AND SUGGESTED RESEARCH

### A. CONCLUSIONS

The research was conducted in several areas of study. These included the information needs of the driver, the interaction between these needs, the factors affecting transmission and reception of information and the systematic means of information presentation. The following conclusions are drawn based on the findings of the reported research:

1. Driver information needs occur throughout the entire driving task, and include pretrip planning.

2. Driver information needs fall into a hierarchy with a distinct primacy relative to satisfying those needs. The hierarchy in the descending order of primacy can be summarized as:

   a. Microperformance Information Needs -- those associated with the two main tasks of tracking and speed control.

   b. Situational Performance Information Needs -- those associated with obstacle aviodance and maintenance of the most efficient and safe course in the traffic stream.

   c. Macroperformance Information Needs -- those associated with trip preparation and direction finding.

3. Use of the primacy concept of information needs is an important requirement of highway information system design. That is, directional (macro) information (lowest on the primacy scale) should not be transmitted when the driver is busy handling micro or situational performance needs. Application of this concept provides the bridge needed to make driver-needs analysis a formal part of field applications of the highway information system.

4. The highway information system must consider all informal and formal information transmission -- for example; pavement and landscaping layout and design and signs and markings, respectively.

5. The basic requirements of the highway information system are:

   a. User centered,

   b. Applicable to existing highways,

   c. Serve all drivers at all times,

   d. Fail-safe,

   e. Compatible and evolutionary,

   f. Economically feasible.

6. The basic design principles for the systematic presentation of information to the driver are:

   a. Observe the primacy concept of transmitting first things first,

   b. Don't overload the driver's processing capabilities,

   c. Require the driver to prepare himself by trip planning,

   d. Spread the transmission of information to avoid overloading and vigilance problems,

   e. Don't surprise the driver -- make information transmitted conform to his expectancy.

7. The transmission of information to satisfy the macroperformance (directional) needs can best be accomplished by using visual communications in the following manner:

   a. Formalizing and improving drivers' trip planning capability. This includes improvements in mapping to correlate highway information and maps, and a system to make maps readily available to drivers. It would also be desirable to have a means of conveniently storing and using the trip plan in the car. This would serve as a step toward eventual automation of display of routing information in the car.

   b. Making maximum use of signs as transmitters by optimizing the use of signs as to location, message content, and design. The major changes in location will result from conforming to the aforementioned primacy and spreading requirements. Major changes in nessage content result from the emphasis on route following instead of destination.

8. Procedures, and a computer simulation, have been developed for the design of signs under conditions of darkness.

9. A procedure has been developed for information system design review which incorporates driver needs analysis, the concept of primacy, and the use of informal aiding techniques in the design of the sign system.

10. Electronic aiding techniques were found to have their maximum potential use in meeting situational and microperformance needs.

## B. SUGGESTED RESEARCH AND DEVELOPMENT

The following areas require further research, experimentation, and/or development:

1. Apply and modify/validate the Information System Design Review Procedure. This procedure incorporates as a basic part, the driver-needs analysis and the concept of primacy. Although this procedure has been partially applied to highway situations, it is essential that the procedure be applied to additional portions of highway to test it under varying conditions.

2. Extend and refine the computer procedure for sign design to include such additional parameters as ambient lighting, headlight glare, multiple car configurations, superelevation, cross-slope and transition curves. Apply the procedure to a gamut of differing field conditions and validate the simulation results by field photometric testing so as to derive a sign design handbook with nomographic solutions for most common design situations.

3. Extend the mathematical analysis of truck blockage to car and truck distributions actually encountered. Validate results of the analysis by field measurements and develop design criteria to minimize this problem.

4. Develop uniform mapping practices that will compliment the highway information system concept. This study determined that trip planning is vital to successful performance of the driving task, and that there is a requirement for good and uniform practice in map preparations relative to driver information needs. Two areas are proposed for study. The first would be the improvement of map information display to compliment the highway information

system. The second, an associated study, would investigate the ability of the driver population to read maps, prepare trip plans, and investigate macroperformance-related driver expectancies. This includes the ability to: (1) understand compass directions, (2) understand weather reports and their use, and (3) translate distance into driving time.

5. Initiate research program on the details of sign design, covering such aspects as:

   a. Optimum arrangement of message,

   b. Advantage of symbolic or schematic signing and, if desirable, how to use it,

   c. Letter design details,

   Since it is concluded that the sign will remain as the key item of the information system, it is essential that its use be optimized. Laboratory research, that is sound from the human factors point of view is needed.

6. Initiate research program on the possibilities of recoding information for both sign and map information presentation. This would cover such aspects as:

   a. Code description of exit type,

   b. Code description of highway type as to speed, clearances, stoppages, etc.

7. Initiate human factors study to quantify human data-processing capability. Although this would require a long-term effort, the System Application Procedures rely on judgments based on this human capability.

8. Perform analysis on aiding to serve the driver in his situational (traffic) needs. A key finding of this study is that development of new aiding techniques (such as measuring the rate of gap closure) should be emphasized to assist the driver in critical need areas. Various aiding techniques have been explored. A systems approach should be used to extend this work to develop an over-all program, or system concept including priorities of development, upon which to base further research work.

9. Perform a systems analysis on system characteristics and techniques for accomplishing alternate routing in highway networks. This macroperformance need warrants a systems approach to lay out a sound program of development.

10. Initiate a study and experimentation program to devise improved means for advising drivers of unusual or unexpected conditions, such as construction, closed, lane, etc.

11. Research is needed in certain areas of aiding devices (other than fixed signs) technology and application. These areas include shape coding of traffic signal lenses, and methods of indicating approach ing termination of the green interval; the optical design, optimum spacing and other aspects of lane control signals; and technology of variable message signs for optimization of detectability and legibility.

# APPENDIX B

# PROGRAM DESCRIPTION - PROGRAM ROADSIGN

## PROGRAM DESCRIPTION--PROGRAM ROADSIGN

### 1. General

The computer program, called ROADSIGN, has been written to simulate a motorist driving a vehicle on a road at night with headlights on, and approaching a sign on the road. The program computes the luminance at the four corners and at the center of the sign as apparent to the driver of the vehicle traveling along an existing, proposed or hypothetical highway and approaching the sign.

The simulation takes into account the following parameters which together constitute the major influences on sign legibility:

a. Distance from sign
b. Automobile headlight output
c. Sign material reflectance
d. Highway alignment and profile*
e. Sign location and attitude with respect to the highway
f. Vehicle geometry
g. Location of driver within vehicle
h. Location of vehicle on highway
i. Atmosphere transmissivity
j. Variations in vehicle voltage as they affect headlights
k. Variations in sign reflectance as typically caused by aging and weathering

*As presently constituted, the program can handle any combination of horizontal and vertical curvature. It cannot handle spirals or other transition curves which must be approximated by circular curves. It also cannot handle crown or super-elevation.

ROADSIGN has been designed to take into account the factors listed above with a high degree of flexibility. In addition, in order to accommodate future expansion, the program has been structured so that additional factors not considered part of the original simulation can be incorporated without revision of the basic program structure.

## 2. Programming Considerations

The program is written in Fortran IV to run on an IBM 360/40 or larger computer. As presently constituted the program will handle up to 100 signs on any length of highway containing no more than 98 horizontal and 98 vertical curves. The program is designed to handle up to 10 different vehicular configurations. The isocandle distribution tables of five common standard headlight types are stored internally, others can be input. The specific luminance tables for three commercially available retro-reflective materials (two types of sheeting and one type of buttons) are also internally stored, others may be input.

The program operates as shown in Figure B-1. The logic functions, in general, so as to determine the location of vehicle headlamps, driver's eyes, and sign (both center and corners) in orthogonal space. It then computes the distances between these three sets of points for each distance stored.

Using the distances computed as well as the inputs describing illumination levels, specific luminance, divergence and entrance angles, and other factors characterizing or affecting light level, the program calculates apparent sign luminance.

Following each set of calculations, the program outputs results via the line printer.

Options available by means of selection of the proper control card include the choice of different types of vehicles approaching the sign of interest, and/or the computation of a number of signs of the same or different configurations placed along the same highway.

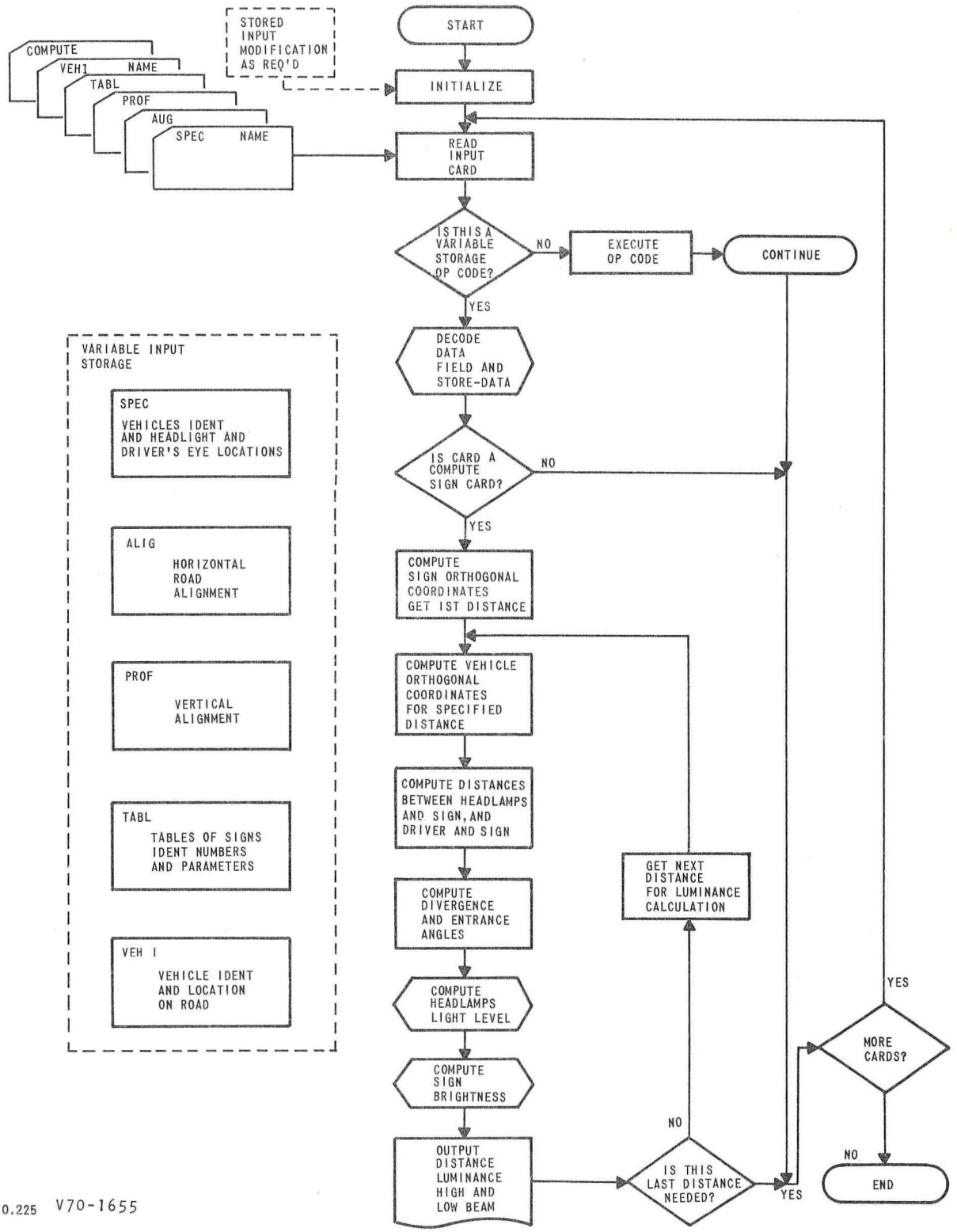


FIGURE B-1. PROGRAM BLOCK DIAGRAM

The specific study reported on herein dealt with an alignment containing 29 horizontal curves and a profile containing 56 vertical curves. The sign table contained a total of 63 signs. The actual computer elapsed time required to calculate the luminance of all the 63 signs as the vehicle approached each sign from 3000 feet to 40 feet was 12 minutes and 47 seconds. This time included reading in and checking the card inputs, storing the information, making preliminary calculations, dumping into the printer these preliminary calculations, further checking and finally outputting 63 pages of luminance values for both high and low beam illumination.